Renewable and Sustainable Energy Reviews 14 (2010) 354–363

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Energy and renewable energy scenario of Pakistan

Munawar A. Sheikh *

Pakistan Council of Renewable Energy Technologies, Plot no. 25, Sector H-9, Islamabad, Pakistan

ARTICLE INFO

Article history:
Received 26 June 2009
Accepted 30 July 2009

Keywords:
Energy
Renewable
Energy planning/status

ABSTRACT

This paper presents a review about conventional and renewable energy scenario of the county in quantitative terms of supply, generation and exploitation of available resources. In this energy scenario, the renewable energy share is in the range of a fraction of a percentage compared to total conventional energy supplies, so depicting it as a sector of least significance for government. Main emphasis in this paper has been given on presentation of data about renewable energy (RE) installations in the country, on-going activities, development projects, RE planning and achievements of public sector RE institutions and organizations. At the end some suggestions are given for effective planning and exploitation of RE resources and use of technologies. These suggestions are not only useful for Pakistan but also are equally important for the third world countries to enhance appreciably RE contribution in their total energy supplies of their country.

Contents

1. Introduction

Pakistan total primary energy supply during fiscal year 2007–2008 was 62.88 MTOE (million tons of oil equivalent) [1]. More than 99% of this energy was supplied through conventional energy sources such as oil, gas, hydel and nuclear, etc. whereas less than 1% supplied through micro/mini renewable energy (RE) stand alone installations while ignoring the fact that many times natural renewable energy resource potential as compared to conventional energy resource exists in the country. In order to facilitate development and generation of alternate or renewable energy to achieve sustainable economic growth with transfer of technology, Government of Pakistan established Pakistan Council of Appropriate Technology (PCAT) in 1975, National institute of Silicon Technology (NIST) in 1981 and Alternate Energy Development Board (AEDB) in 2003. In May 2001 NIST and PCAT merged to

* Tel.: +92 51 2535178.
E-mail address: sheikh173@yahoo.com.

1364-0321/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2009.07.037

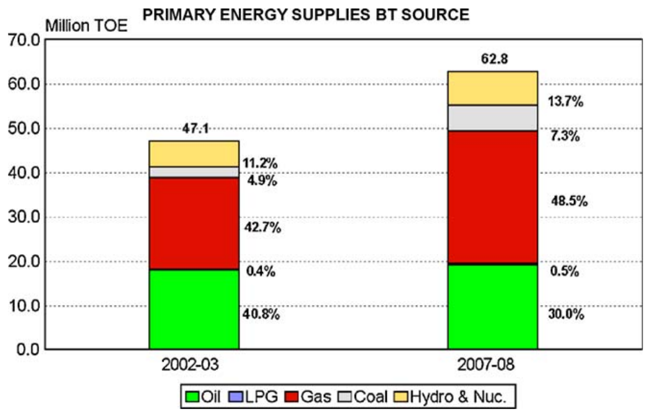


Fig. 1. Primary energy supplies by source.

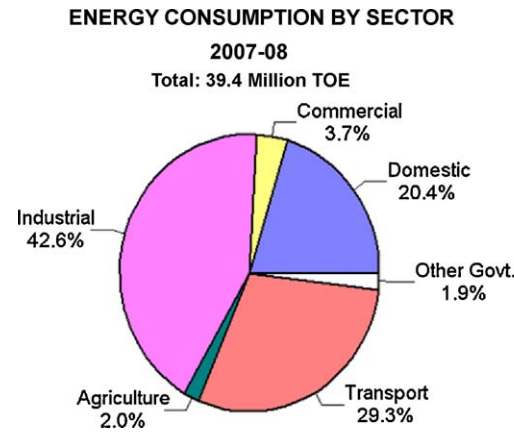


Fig. 2. Sector-wise energy consumption.

become Pakistan Council of Renewable Energy Technologies (PCRET) thus having two main departments, AEDB and PCRET, in government sector for execution and implementation of renewable energy projects. Due to lack of precise promotion instruments for renewable energy technologies, the output of all solar and wind energy systems plus mini/micro hydropower plants together amounted to less than 3 MW at the end of 1990s. In 1992, Pakistan National conservation Strategy (PNCS) was announced to introduce biogas, wind power and mini hydropower facilities. In October 1997, National Environment Action Plan-Support Programme (NEAP-SP) was signed between Government of Pakistan (GoP) and UNDP. The NEAP-SP includes six different sub-programmes, one of which concerns the field of energy conservation and renewable energy sources, and concrete projects are to be implemented over the next 5 years. In 2005, AEDB was having a mandate of generating 10% of the total installed capacity in the country from renewable energy sources by 2015. But in spite of all these facts, an appreciable amount of development could not be seen in the country resulting in ever worse energy crisis in the country in the current year. In the following sections, a picture about conventional and renewable energy utilization/generation is given along with renewable energy projects being executed in the country. At the end, some suggestions are proposed for effective dissemination of RET in the country.

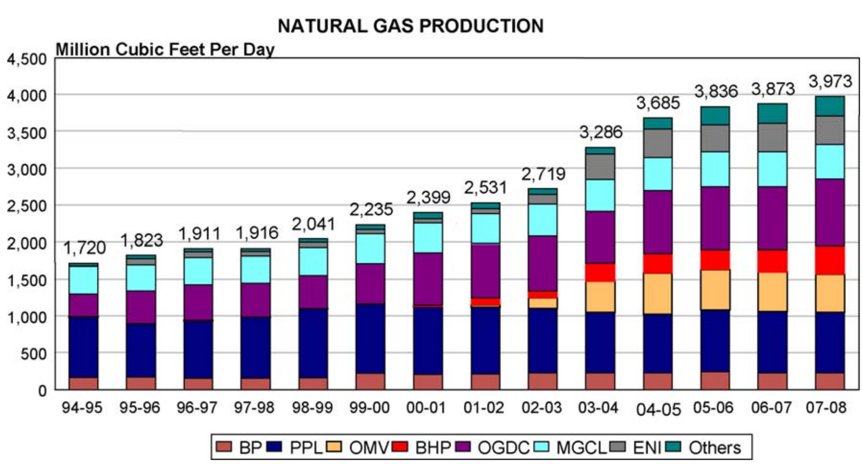


Fig. 3. Natural gas production per day.

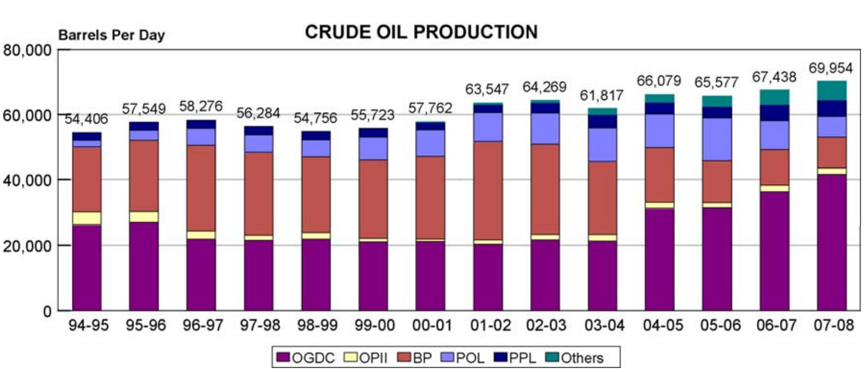


Fig. 4. Crude oil production per day.

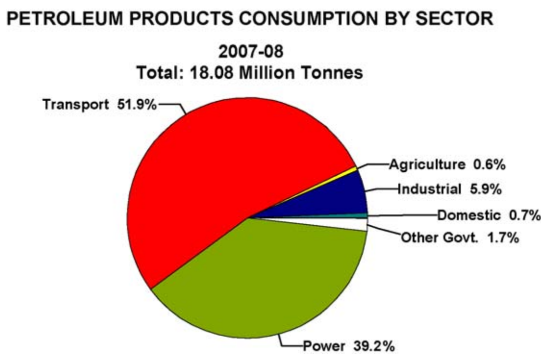


Fig. 5. Sector-wise petroleum products consumption.

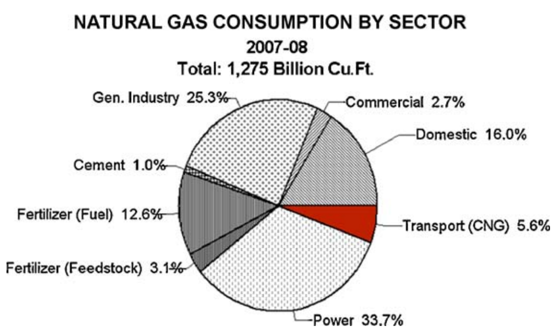


Fig. 6. Sector-wise natural gas consumption.

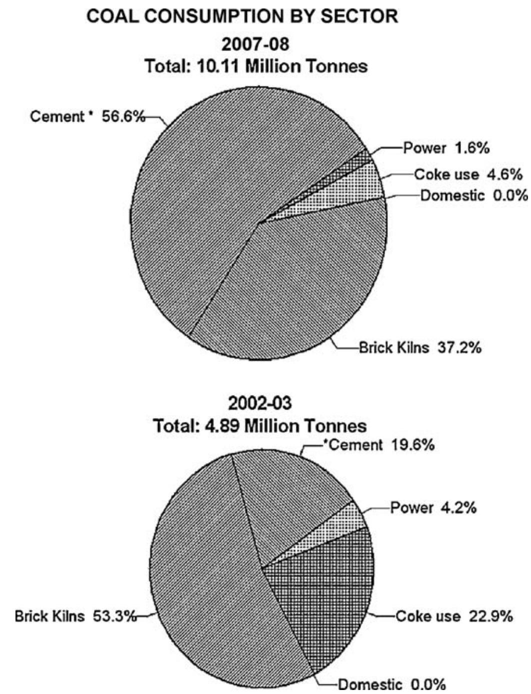


Fig. 8. Sector-wise coal consumption.

2. Conventional energy

The conventional energy supplies, generation/production and consumption in the country have been shown in Figs. 1–11. The total primary commercial energy supplies during year 2007–2008 was 62.88 MTOE (million tons of oil equivalent), Fig. 1, with an increase of 3.8% as compared to preceding year and 33.3% as compared to year 2002–2003. The growth rate has decreased slightly from 4.4% last year. The share of natural gas in primary energy supplies by source was 29.87 MTOE (47.5%) followed by oil 19.20 MTOE (30.5%), hydro electricity 6.85 MTOE (10.9%), coal 5.78 MTOE (9.2%), nuclear electricity 0.73 MTOE (1.2%), LPG 0.41 MTOE (0.7%) and imported electricity 0.04 MTOE (0.1%).

The final energy consumption by sector during year 2007–2008 was 39.41 MTOE, Fig. 2 while excluding consumption for power generation and feedstock. In this sector-wise consumption the highest consumption is of gas 15.881 MTOE (40.3%) followed by oil 11.528 MTOE (29.3%), electricity 5.977 MTOE (15.2%) and coal 5.404 MTOE (13.71%), etc. The total T&D losses during year 2007–2008 were 1.746 MTOE (2.8% w.r.t. energy supplies).

Natural gas production during the year increased from 3873 to 3973 million cubic feet per day (2.6% increase), Fig. 3 while oil production increased to 69,954 from 67,438 barrels per day (3.7% increase), Fig. 4. Oil consumption, Fig. 5, increased by 7.3% during 2007–2008 over the preceding year. Main increase was in transport sector (18%) followed by domestic (14%), agriculture (12%) and power (5%) sectors. The consumption declined in industry and other government sectors by 33% and 5%, respectively. Natural gas consumption, Fig. 6 increased slightly by 4.4% during 2007–2008 as compared to previous year. Main increase was in transport sector (28%) followed by domestic (10%), commercial (8%) and industry (5%), whereas natural gas consumption decreased in cement industry by 13% and power sector by 1% over the previous year. Coal production, Fig. 7, increased by 13% in 2007–2008 due to multifold increased production from

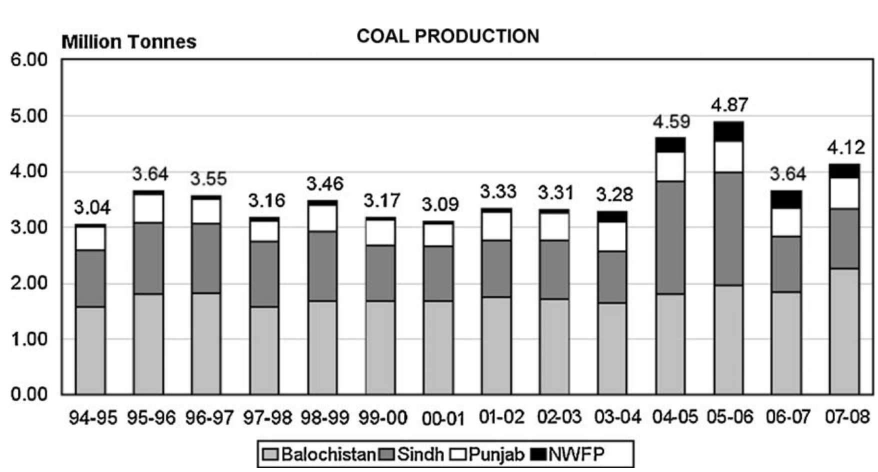


Fig. 7. Province-wise coal production.

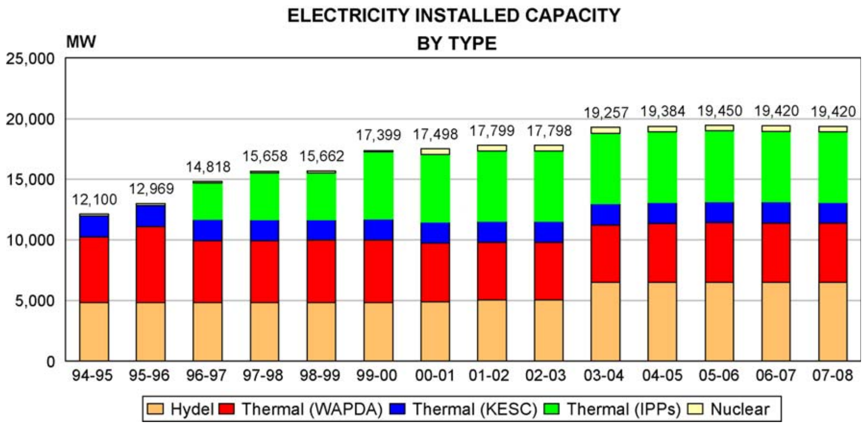


Fig. 9. Type-wise electricity installed capacity.

Barkhan coalfield in Balochistan. The coal imports have also gone up by 40.8% resulting in overall increase in coal supplies consumption by 28.1% over the last year. The coal consumption by sector has been shown in Fig. 8. The installed capacity of electricity generation as reported on June 30, 2008 was 19,420 MW. In hydel, Tarbella, Ghazi Brotha and Mangla dams are major contributors with 3478, 1450, and 1000 MW power generation, respectively. Whereas in thermal, WAPDA, KESC and IPP's are main contributors with 4900, 1756 and 5822 MW power generation, respectively.

Electricity generation, Figs. 9 and 10 during year 2007–2008 decreased by 2.6% (with 10.2% decrease in hydel generation) over the last year and reached 95,860 GWh (including 199 GWh of electricity imported from Iran). Electricity generation included

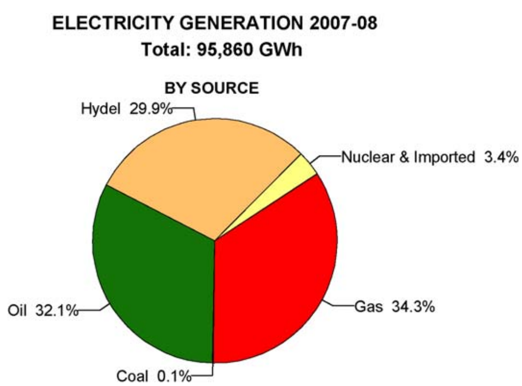


Fig. 10. Electricity Generation in year 2007–08.

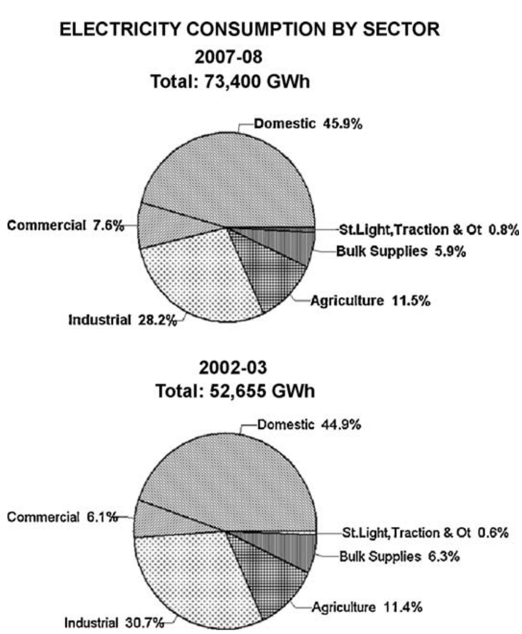


Fig. 11. Sector-wise Electricity Consumption.



Fig. 12. Solar electrification of a rural house.



Fig. 13. Solar water heating system installed in Islamabad.



Fig. 14. Solar dryer installed for drying of dates.

64.25% thermal, 33.4% hydel, 2.4% nuclear shares while 0.2% of the electricity was imported. Electricity consumption, Fig. 11 increased slightly by 1% to 73,400 GWh during 2007–2008 as compared to 72,712 GWh last year. Major increase in consumption was in domestic (369 GWh), commercial (209 GWh) and agriculture (296 GWh) sectors while the electricity consumption in industrial sector showed a decrease of 337 GWh. T&D losses in case of electricity have been reported upto 19.5% which are in fact quite high and must be reduced and controlled.

The crude oil and natural gas reserves as reported on June 30, 2008 were 43.83 and 551.22 MTOE, respectively. With present rate of consumption, the reserves are sufficient for meeting oil and gas energy demands of next 2.28 and 18.45 years, respectively. The coal reserves as reported on June 30, 2008 were equivalent to 83,262 MTOE and sufficient to sustain alone whole energy supplies for next 1324 years at present rate of consumption. The 99% of these coal reserves are in Sindh province mostly with ASTM classification of sub-bituminous A/C and Lignite A/B coal.

To enhance hydropower generation, there are five hydropower projects under construction, e.g., Allai Khwar, Khan Khwar, Duber Khwar, Jinnah and Neelum Jhelum hydropower projects. Whereas dams under construction are Gomal Zam Dam, Mirani Dam, Sabakzai Dam, Satpara Dam and Mangla Dam Raising project. The future projects announced by the top authorities of Pakistan include Diamer Basha Dam, Kalabagh Dam, Kurram Tangi Dam, Munda Dam and Akhori Dam projects. The hydropower projects about which feasibility study is being conducted includes Golen Gol, Dasu, Bunji, Keyal Khwar, Lawi, Pallas Valley (Chor Nullah), Spat Gah, Basho, Phandar, Jabban, Thakot and Patan hydropower projects.

For Oil and gas exploration, 27 exploratory wells were drilled during year 2007–2008 as compared to 36 during 2006–2007 and 33 during 2005–2006 showing a slow progress in drilling activity. The number of development wells drilled during 2007–2008 was 53 as against 41 during 2006–2007 and 31 during 2005–2006. The drilling efforts resulted in 11 discoveries mostly of gas/condensate, out of which five were by OGDCL and six by other companies. The overall discoveries as reported on July 2008 are 213 of which 67 are of oil and 146 of gas/condensate with overall success rate of 1:3.4.

3. Renewable energy

In Pakistan, potential for almost all types of renewable energies exists in the country. These types include solar (PV and thermal), wind, biogas, microhydel/canal fall, biodiesel production, biomass/waste to energy production, geothermal, tidal/ocean energies, etc. Among these, biodiesel and biomass/waste to energy production is under development or project implementation stage whereas geothermal and tidal/ocean energies utilization are in feasibility study process. The resource potential about most of these renewable energies in the country has already been discussed [2–4] but in this paper its exploitation, RET status/measures and plans will be discussed along with activities/achievements of the renewable energy organizations of the country.

3.1. Solar energy

On average solar global insolation 5–7 kWh/m^2/day exists in the country over more than 95% of its area with persistance factor of over 85% [2–3]. The South Western province of Balochistan and North Eastern part of Sindh offer excellent conditions for harnessing solar energy where sun shines between 7 and 8 h daily or approximately more than 2300–2700 h per annum. Despite the favourable conditions, the use of solar energy for generating electricity or heating is still in its beginnings. Mostly photovoltaic systems of generation capacity 100–500 W/unit have been used for producing electricity in a few rural areas. Figs. 12–14 show some of installations of photovoltaic and solar thermal systems. According to a survey report, more than 40,000 villages of Pakistan have no access to electricity [5] and it is expected that within next 50 years, it is difficult to electrify these villages with present pace of development in the energy sector. As far back as the early 1980s, the Government of Pakistan had 18 PV systems with a composite output of 440 kW installed in various parts of the country. Due to lack of technical know-how about operation and maintenance, these systems were no longer in operation in 1990s. Under such conditions PCRET started ensuring development and sustainability of solar and other renewable energy projects in the country. AEDB joined such efforts in 2003. But unfortunately both these governmental organizations are so weak in financial and technical manpower resource to imagine any breakthrough in near future. More than 20 manufacturers, suppliers, etc. in private sector are active in solar energy business in the country. AEDB electrified approximately 3000 households with total PV power generation of 200 kW in districts of Kohat (NWFP), D.G. Khan, Rawalpindi (Punjab), Tharparkar (Sindh), Turbat/Kalat (Balochistan), etc. while providing 80 W panel with lighting system to each household. PCRET electrified more than 500 schools, mosques, houses through PV power with total generation capacity of more than 80 kW. In private sector, the PV installations in the country are approximately in the range of 500 kW. In future PV stand alone micro projects are being planned in the country instead of initiating any mega/macro PV project on commercial scale to overcome the energy crisis of the country through available solar resource. In solar thermal side, solar cookers (box and concentrated type), solar dryers/desalination units, solar water heaters, etc. have been designed, developed and are in limited use but their contribution in energy provision is negligibly small. So the total installation appears to be much less than 1000 kW in PV and 10,000 solar thermal units (all kind) in the country.

3.2. Wind energy

Wind speed 5–7 m/s persists in coastal regions of Sindh [6] and Balochistan provinces and in a number of North West frontier valleys. According to a survey, Pakistan possesses more than 20,000 MW of economically viable wind power potential. But by the end of year 2003, not a single wind energy conversion system with a generating capacity above 500 W had been installed in the country. There were only a small number of micro-plants (300–500 W) for generating electricity and more than 100 wind power



Fig. 15. Electrification of a village in Sindh province through wind energy.



Fig. 16. Wind Turbine installed for powering of a house.

installations in use for pumping water in the coastal regions of Balochistan and Sindh provinces. The present working status of these wind power installations is also questionable. During the last 3 years, PCRET installed 130 units of total generating capacity of 143 kW with wind turbines of 0.5–10 kW capacity/unit while electrifying 1430 houses. Photographs of such installations are shown in Figs. 15–16.

On commercial grid connected electricity generation programme, the Government of Pakistan decided to install 100 MW wind power form at Gharo-Keti Bendar through AEDB during the year 2005 but the programme is still in its beginning of implementation. 100 MW Kenetech wind power project in Balochistan province and 150 MW Omega Zond wind farm in Sindh province which were being planned to implement in 2000s with co-operation of two American investors could not be implemented. Similarly projects initiated in 2001 under GEF Operational Programme OP6 with co-financing from UNDP and the Nordic trust for commercial scale exploitation of wind energy for power generation also ended with no outcome. The lack of proper planning, cost analysis, availability of wind data and provision of adequate incentives to investors are perhaps main reasons behind this. Recently in April 2009, AEDB inaugurated 4 MW grid interactive wind power station at Gharo, Sindh which is the biggest installation so far in the country. AEDB installed 40 wind turbine in Karachi with total generation capacity of less than 10 MW and also installed micro-turbines of 500 W in various universities of Balochistan for R&D purposes. Presently AEDB is working on wind mapping project. PCRET has installed 135 units of micro wind turbine in Sindh and Balochistan province while electrifying 1431 houses with wind power generation of more than 151 kW. Gul Muhammad village in Sindh was the first village in Pakistan electrified through wind energy by PCRET by installing 26 micro-units of 500 W each in this village.

3.3. Microhydel

More than 1200 MW micro/mini hydropower potential is estimated to be available in the country while including power generation at northern mountainous region and southern plane region including energy generation through canal fall also [7]. Out of this potential, less than 5% is being developed. For microhydel power plants with capacities 100 and 500 kW each, an estimated potential of 300 MW and more than 400 MW, respectively exists in Northern Area only. As of today, less than 50 MW of that potential had been tapped by a total of more than 300 projects co-financed by Aga Khan Rural Support Programme (AKRSP), PCRET/MoST, European Union (EU), AEDB and private developers. Now, with assistance of the Asian Development Bank and within the scope of Malakand Rural Development programme, 100 microhydel power plants with ratings ranging from 5 to 50 kW have recently been completed within and around Malakand division of the North West Frontier Province (NWFP). Figs. 17–18 depict some of microhydel installations in Pakistan.

AEDB is installing microhydel power plants of total generation capacity of 10 MW in Punjab, NWFP and Northern Area and will be



Fig. 17. Installation of a microhydel turbine at canal.

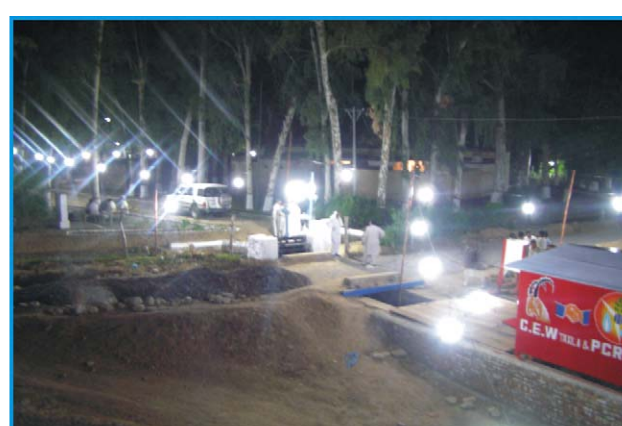


Fig. 18. Powering of Garden Lights through microhydel system.

commissioned by 2012. Projects of 187 MW are also under feasibility study and these include:

- Jagran-I hydropower project of 30.4 MW at Azad Jammu and Kashmir.
- Naltar Gah Ph-V hydropower project, 17.34 MW at Northern Area.
- Kargah Ph-VI hydropower project, 4 MW, Northern Area.
- Kachura Ph-III hydropower project, 3 MW, Northern Area.
- Chilas Ph-II hydropower project, 2 MW, Northern Area.
- Kundal Shahi Hydropower project, 2 MW, Azad Jammu and Kashmir.

AEDB other projects under feasibility study include more than 30 installations of 0.1 to 2 MW mostly at Northern Areas. AEDB is having financial and technical co-operation with Agha Khan Foundation, UNDP, GEF, ADB and GTZ, etc. for its hydropower projects. PCRET has installed microhydel power plants of total generation capacity more than 5 MW through units of 5–50 kW each. These installations are mostly in NWFP, Northern Area, Balochistan, etc. at Abbottabad, Mansehra, Batagram, Kohistan, Swat, Shangla, Bunair, Chitral, Dir, Kohat, Khyber Agency, Bajur Agency, Aurakzai Agency, Diamir, etc.

3.4. Biogas

Total biogas generation potential of 14.25 million m^3/day is available in the country [2,4]. Pakistan Council of Renewable Energy Technologies is designing, developing and disseminating biogas plants in the country. During the last 3 years, more than 1600 plants mostly of 5 m^3/day capacity have been installed by PCRET. NGO's and private sector companies have done approximately the same no. of installations. This means that total of 0.016 million m^3/day biogas capacity was tapped during last 3 years with annual exploitation factor of 0.374×10^{-3}. The working status of biogas plants installed before last 3 years is uncertain as back up service for repair and maintenance lacks. Figs. 19–20 are photographs of biogas plants being used for generation of fuel gas in rural areas of Pakistan. The layout of 5 m^3 plant with its technical specifications is shown in Fig. 21 for the benefit of engineers/people working in bio-energy field. The life of these plants is being estimated up to 5 years. It is strongly being felt that high technology digesters generating more gas with capability of sustaining internal temperature under adverse environmental conditions and better life span should be adopted and installed in the country. Biogas plants are gaining high popularity among farmers of Punjab province especially in Bahawalpure area.



Fig. 19. Biogas plant of more than 10 m^3/day capacity.

AEDB is working on biogas project at Landhi cattle colony, Karachi and pilot phase of the project will be funded by New Zealand Aid (NZAID). Waste from 400,000 cattle in the area would be utilized to generate electricity through biogas plants/generators and high grade organic fertilizer. The pilot phase of the project will generate 250 kW of electricity through biogas whereas generation capacity will be extended to 30 MW along with production of 1500 ton of organic fertilizer per day. A photograph of the project is shown in Fig. 22. Another biogas power generating plant with a capacity of 8.25 MW is under construction in Shakarganj Mill with the technical assistance of AEDB.

3.5. Geothermal energy

Although there are numerous hot springs with temperature ranging from 30 to 170 °C in various parts of Pakistan [2,8] for example in the vicinity of Karachi and in the Pakistani part of the Himalayas but there has been no attempt to make use of geothermal energy in Pakistan yet.

4. Renewable energy institutions/departments

4.1. PCRET

The leading organization in Pakistan in the field of renewable energy sector is known as PCRET established in May 2001 by merging Pakistan Council of Appropriate Technology (PCAT) and National Institute of Silicon Technologies (NIST). During the last 7 years, PCRET has done research and development activities in various fields of renewable energy technologies. These fields include photovoltaics (PV), solar thermal energy (STE), wind energy (WE), biogas and biomass (BG/BM), microhydel power generation (MPG), fuel saving technologies (FST), etc. As a outcome of its R&D activities the following products and process have been developed which are of immense use for industrial and domestic applications.

Products	Processes
Photovoltaic	
(a) Solar street lights	(a) Silicon single crystal growth process
(b) Solar garden lights	(b) Solar cells manufacturing process
(c) Solar torch/portable lights	(c) PV module lamination process
(d) PV mobile charger	(c) PV device testing process
Solar thermal	
(a) Solar cooker (box type and concentrator type)	(a) Solar thermal appliances testing and performance evaluation process
(b) Solar dryer/dehydrator	
(c) Solar water heaters	
(d) Solar stills/desalination units.	
Other renewable energy plants/systems	
(a) Micro/mini hydel power plants	
(b) Biogas plants	
(c) Solar home systems	
(d) Etc.	

For the application of PCRET research to the benefits of the society, the following development was carried out by PCRET during the last 7 years [7]:

(i) 90,000 efficient cook stoves disseminated throughout the country with annual financial savings of fuel wood worth of Rs. 86 million (more than US$ 1 million).
(ii) 1600 Biogas plants installed for meeting domestic fuel needs of households besides producing bio-fertilizer. The annual biogas generation capacity of these plants is more than 2.5 million m^3 along with production of 4 million kg/year of bio-fertilizer.



Fig. 20. Biogas plant of 5 m^3/day capacity.

(iii) Installation of 130 wind turbines for electrification of 430 houses in the remote coastal villages.
(iv) Installation of 360 microhydel power plants with generation capacity of 5 MW in NWFP, Northern Areas and FATA. The power generated by more than 50 MHP plants is being used exclusively by small scale industrial units, e.g., rice sheller, flour mills, saw machines, lathe machines, welding plants and grinding machines, etc.

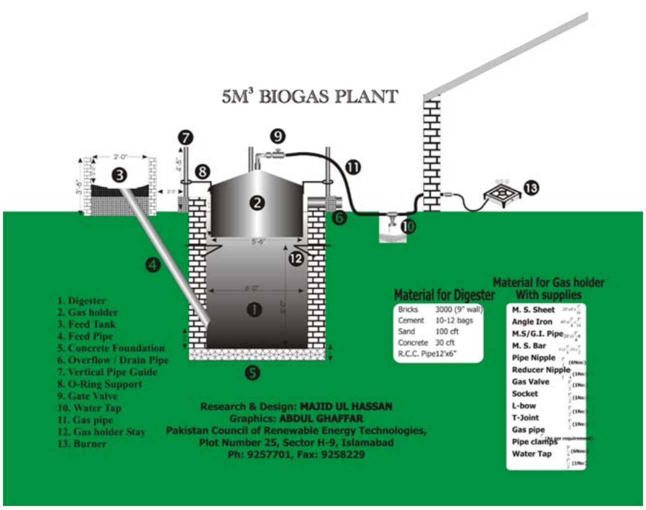


Fig. 21. Schematic layout of 5 m^3/day capacity biogas plant.



Fig. 22. Plant under construction through co-operation of New Zealand for generation of 250 kW of electricity from biogas.

(v) More than 200 solar photovoltaic power systems installed throughout the country for lighting and water pumping purposes. The generation capacity of most of individual PV systems is in the range of 200–500 W. The total PV generation capacity is more than 80 kW.
(vi) Hundreds of solar cookers (box and concentrated type), more than 100 solar water heaters and solar dryers distributed throughout the country.

All these deployments are clean, environment friendly and carbon free sources of energy and contributing their role for reducing environmental health hazards to the society.

PCRET's other research and development activities during last seven years includes:

(i) Production of solar cells/PV panels of various ratings with total annual production of 15 kW. Its up-gradation upto 80 kW generation capacity under implementation now-a-days.
(ii) Design and development of Kaplan turbine.
(iii) Establishment of testing laboratory for photovoltaic and solar thermal appliances and systems as per international standards.
(iv) Development of community size solar dryers for drying of dates and apricot.
(v) Electrification of four remote area villages through solar energy.
(vi) Development of organic solar cells.
(vii) Design and development of low powered solar lights.
(viii) Up-gradation and extension in lab facilities.
(ix) Installation of hundreds of microhydel power plants.
(x) Establishment of five renewable energy training centers.

PCRET has published more than 200 publications at international and national level.

4.2. AEDB

Alternate energy development board (AEDB) was founded in 2003 for supplying wind, solar and mini/small hydropower generated electricity to remote regions of Pakistan. AEDB is also responsible for developing the country's medium and long-term promotion policy for exploitation of renewable energy resources. In addition, its functions include the co-ordination of joint ventures with the aim of having foreign technologies in the field of alternative energies. AEDB has mobilized different sources of funds from the international donor organizations, i.e., ADB, GEF, USAID, GTZ and UNDP for the promotion, execution and implementation of alternative renewable energy projects in

Pakistan. AEDB is a member of the Board of Directors of the World Energy Society (ISES). Presently AEDB is working on [9]:

- Design and development of 100 MW wind farm at Gharo-Keti Bandar, Sindh.
- Electrification of 800 remote area villages through renewable energy technologies.
- Indigenous development of wind turbines.
- Indigenous development of solar PV panels.
- Establishment of solar thermal power plants in the country.
- Formulation of laws and taxes to promote and encourage ARE projects and products in the country.

AEDB is planning to install an additional 300 micro wind turbines and has issued letter of intend (LOI's) to 22 national and international companies for generation of power in megawatt through wind energy. AEDB has also signed an agreement with KPT for generation of 50 MW wind power. The purpose of such projects is to expand the use of available renewable energy sources.

Realizing the importance of biodiesel, AEDB has initiated National Biodiesel programme and formulated a policy for the use of biodiesel as an alternate fuel in Pakistan. The policy is primarily aimed at reducing the country's fuel import bill, promoting the demand for biodiesel raw material which will be the primary commodity for biodiesel production. The policy has been approved by the Economic Co-ordination Committee (ECC) of the federal cabinet and one of the salient features of the policy is to achieve a minimum biodiesel share of 5% by volume of total diesel consumption in the country by the year 2015 and 10% by 2025. A village of Goth Umar Din Arain in tehsil Ghora Bari district Thatta, Sindh has successfully been electrified through power produced by biodiesel generator while providing two energy savers and a bracket fan to each house.

4.3. NESCOM and SEC

National Engineering and Science Commission (NESCOM) and Solar Energy Center (SEC) are two other organizations working in some areas of solar energy. NESCOM and SEC are mostly concentrating on production of photovoltaic panels and designing of solar thermal appliances, respectively. The area of work of these two departments is very limited. SEC is an attached department of Pakistan Council of Scientific and Industrial Research (PCSIR) and has designed and developed solar flat plate water heating system in 1980s. SEC has also installed 500 gallon per day capacity solar desalination system near Gwader, Balochistan Province for disinfection and purification of drinking water.

4.4. Private sector companies

In private sector, more than 30 companies are in renewable energy business in the country. Mostly retail and wholesale suppliers, importers/exporters, etc. whereas a few are manufacturer of renewable energy products. These companies are mostly supplying small electric/thermal units. Akhter Computers, MEFT Ltd., International Industrial Solutions Ltd. Solar Energy Technologies, Adaptive Technologies, etc. are well known companies in RET business. Some NGOs/companies in collaboration with international donor agencies are trying to install wind farms in the country. The total solar installation mostly for home lighting purposes by these companies is less than 1000 kW in the country whereas wind power generating units with total capacity in megawatts are being designed by some private sector organizations. Whether they will be able to implement such wind projects in near future bears a question mark. Even then the quality and sustainability of these projects are another points of consideration. The cost of the RET systems provided by these private companies is so high that it is not affordable by people which is one of main hurdles in dissemination of renewable energy technologies in the country.

5. Suggestions

Following suggestions are given for development, dissemination and better and efficient use of renewable energy technologies in the country:

- Being enriched of nature gifted renewable energy resources, Pakistan must generate 10% of its energy demand through renewable energy technologies at least by 2014. To achieve such objectives, Government of Pakistan must have to formulate such laws and policies which encourage also private investors (local and foreign) to invest for the establishment of power/energy generating units. Tax rebate and financial leasing through banks or institutions must have to be opted as part of national renewable energy policies.
- RET large and commercial scale projects have not yet been initiated in spite of the fact that government institutions are working in renewable energy fields for the last more than two decades. Such projects remained in documents with planning wings but implementation is still not seen. Low powered generating units cannot meet energy demands of 160 million people, 95% of whom are not in position to afford cost of even micro/mini systems. So commercial and grid connected RET projects are suggested to start with immediate effect.
- Quality of installation and technology used must be improved. ISO/IEC international standards must be followed for designing and erection of systems. Security standards are being ignored as no. of casualties especially of children have been reported. So adoption and implementation of international standards is suggested.
- Honesty and dedication to national interests is being superceded by personal benefits of the responsible authorities which must be countered through effective control and monitoring measures at government level. This is one of the main hurdles for dissemination of technology in the country. Mere demand of finances and release of funds for RET projects is insufficient to bring technological revolution. So formulation of effective monitoring and evaluation system at government level is suggested.
- Human resource development (HRD) in the field of renewable energy technologies must be emphasized. Such objectives can be achieved through introduction of RET courses at university level for graduation/post graduation purposes and also provision of attractive salary package to RET scientists and engineers. So far such incentives have not been taken at government level in spite of the fact that its importance was realized two/three decades before.
- Manufacturing of RET plants be initiated in the country through transfer of technology from advanced countries. Apparently there is no ban on transfer of such technologies at international level but it is just a lack of planning, co-ordination and collaboration with other countries at government level. So transfer of RET technologies must be done on top priority.
- Energy efficient, low cost and reliable systems be introduced in the country. Government department must have quality control checks through certification process. At present, such practice is not being exercised, hence causing damage to the reputation and use of RET products in the country. So establishment of certification labs for RET products at government level is suggested.

6. Conclusion

Pakistan must concentrate on generation of an appreciable amount of energy through renewables in which a huge resource potential exists in the country. Unfortunately so far total RE contribution in the energy mix scenario of the country is less than 1%. If RE technology would have developed and RE products had been made cost effective through financial leasing or subsidy, it would have contributed energy generation share up to 30% relative to total energy demand by year 2008. The organizational structure, RET, HRD, government planning, RET project execution and financing, private partnership programme, use of technology, incentives to local and foreign investors/stakeholders and co-ordination with international agencies for joint projects, etc. need to be improved. This will not only save foreign exchange, more than 60% of which is being utilized for import of energy, but will also bring economic stability and prosperity in the country. If Pakistan re-structures its energy policies on the suggestions given in this paper, a green revolution can be foreseen in the country within next one or two decades while building up self-reliance and self-sufficiency in energy production through renewables and it is expected that Pakistan may become a role model for third world and the least developed countries to follow.

References

[1] Pakistan Energy Year Book. Hydrocarbon Development Institute of Pakistan, Ministry of Petroleum and Natural Resources, Islamabad, Pakistan; 2008.
[2] Sheikh MA. Renewable Energy Resource Potential in Pakistan. Renewable & Sustainable Energy Reviews, 2009, accepted for publication.
[3] Shamshad KM. Solar insolation over Pakistan. J SES (Taiyo Enerugi) 1998; 24(6):30.
[4] Ghaffar MA. The energy supply situation in the rural sector of Pakistan and the potential of renewable energy technologies. Renewable Energy 1995;6(8):941.
[5] Pakistan Economic Survey, 2006–2007, Government of Pakistan.
[6] Technical Report no. PMD-07/2007. Pakistan Meteorogical Department. Wind Power Potential of Sindh.
[7] Internal Report 2008. Pakistan Council of Renewable Energy Technologies (PCRET). Islamabad, Pakistan.
[8] Tauqir A, Shuja. Geothermal areas in Pakistan. Geothermics 1986;15(5–6): 719–23.
[9] Internal Report, 2008, Alternate Energy Development Board (AEDB), Islamabad, Pakistan.